PATENT ABSTRACTS OF JAPAN

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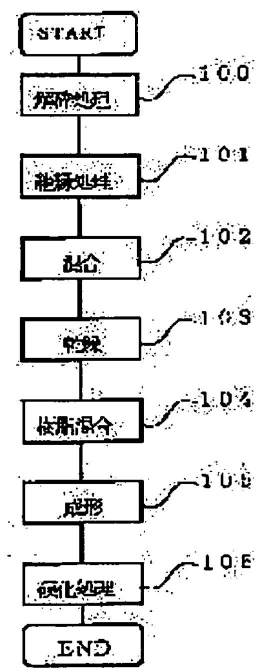
(54) METHOD AND DEVICE FOR MANUFACTURING DUCT CORE

(57)Abstract:
PROBLEM TO BE SOLVED: To suppress eddy current loss in a dust core by perfectly forming an electric insulating layer for each magnetic powder grain.
SOLUTION: In a step 100, a cracking process wherein a secondary coagulation of the magnetic powder is released is performed. This cracking process is performed before an insulation process in the net step 101. The magnetic powder wherein the secondary coagulation is released is performed with an insulation process in the step 101, for evenly forming an electric insulation layer on each surface of the magnetic powder. The magnetic powder wherein the electric insulation layer is formed on the surface is mixed in a step 102, and dried in a step 103. Then in a step 104, a polyimide resin, etc., is added as a bonding agent to the magnetic powder for mixing. After that, in a step 105, it is molded to a dust core under compression. Lastly, it is dried in a step 106.



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CLAIMS

[Claim(s)]
[Claim 1] The manufacture approach of the dust core characterized by to perform crack processing which unravels secondary condensation of said magnetic powder before formation of said electric-insulation layer in the manufacture approach of the dust core which manufactures a dust core by mixing and fabricating resin into the magnetic powder in_which the electric insulation layer was formed while carrying out insulating processing of the magnetic powder and forming an electric insulation layer in the front face of the magnetic powder concerned.
[Claim 2] The manufacture approach of the dust core characterized by drying this mixture and carrying out insulating processing of said magnetic powder after mixing the insulating stratification processing liquid which contains phosphoric acid, boric acid, magnesium ion, a surfactant, and a rusr-proofer in said magnetic powder which performed said crack processing in the manufacture approach of a dust core according to claim 1.
[Claim 3] It is the manufacture approach of the dust core characterized by being carried out when said crack processing gives an impact and vibration to magnetic powder in the manufacture approach of a dust core according to claim 1 using the mixer or ball mill of a V type or W cone mold.
[Claim 4] An insulating processing means to carry out insulating processing of the magnetic powder, and to form an electric insulation layer in the front face of the magnetic powder concerned, In the manufacturing installation of a dust core including a mixed means to mix resin into the magnetic powder with which said electric insulation layer was formed, and a shaping means to fabricate the magnetic powder after resin mixing and to manufacture a dust core The manufacturing installation of the dust core characterized by establishing a crack processing means to perform crack processing which unravels secondary condensation of said magnetic powder before formation of said electric insulation layer.
[Claim 5] It is the manufacturing installation of the dust core characterized by being the mixer or ball mill of the V type or W cone mold with which said crack processing means gives an impact and vibration to magnetic powder in the manufacturing installation of a dust core according to claim 4.
[Claim 6] Magnetic powder characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 5 - 10% of -74-62 micrometers, the particle size of -62-45 micrometers, and 5% or less of 45-micrometer or less particle size by weight.
[Claim 7] Magnetic powder characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 10 - 20% of -74-62 micrometers, 10 - 20% of particle size of -62-45 micrometers, and 10 - 20% of 45-micrometer or less particle size by weight.
[Claim 8] It is the core which said magnetic powder is weight in the core which mixed to resin the magnetic powder which has an electric insulation layer, and was fabricated, and be characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 5 - 10% of -74-62 micrometers, the particle size of -62-45 micrometers, and 5% or less of 45-micrometer or less particle size.
[Claim 9] In the core which mixed to resin the magnetic powder which has an electric insulation layer, and was fabricated, said magnetic powder is weight. The core characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 10 - 20% of -74-62 micrometers, 10 - 20% of particle size of -62-45

micrometers, and 10 - 20% of 45-micrometer or less particle size.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of a dust core, and a manufacturing installation.
[0002]
[Description of the Prior Art] Generally, the dust core is used as high frequency coils, such as a transformer for high frequency, a reactor, a thyristor bulb, a noise filter, and a choke coil. Such a dust core is low iron loss, and it is called for not to mention being high flux density that those magnetic properties do not fall in a RF field.
[0003] There are eddy current loss with deep specific resistance value and relation of a core and hysteresis loss produced from the manufacture process of magnetic powder (iron powder) and subsequent process hysteresis in iron loss. Among these, since eddy current loss becomes large in proportion to the square of a frequency, in order to raise the property in a RF, it becomes important to lower eddy current loss. Since what is necessary is just to confine an eddy current in a small field for lowering eddy current loss, generally the dust core is manufactured from the magnetic powder with which each particle was insulated.
[0004] While mixing resin as adhesives into the magnetic powder with which insulating processing of the magnetic powder was carried out, the electric insulation layer was formed in the front face of magnetic powder as the conventional manufacture approach, and the electric insulation layer was formed, it fabricates by compression, and the manufacture approach of the dust core which manufactures a dust core is learned.
[0005] However, by the above-mentioned manufacture approach, there is a fault that eddy current loss becomes it large that the insulation by the electric insulation layer is inadequate. Although it is possible to thicken an electric insulation layer in order to improve insulation, if an electric insulation layer becomes thick, the rate that the magnetic powder in a core occupies will fall, and flux density will fall as a result. Moreover, if a consistency is raised and it presses by the high-pressure force utterly in order to raise flux density, the distortion at the time of shaping will become large, and hysteresis loss will become large and will cause increase of iron loss.
[0006] In order to manufacture a good dust core, without lowering a consistency, it is important to raise the specific resistance of a dust core, and it is required to cover magnetic powder in a thin and good insulating electric insulation layer for that purpose.
[0007] Performing phosphate chemical conversion to magnetic powder as an approach of forming such an electric insulation layer is indicated in JP,6-260319,A, JP,62-22410,A, JP,63-70504,A, etc.
[0008] Moreover, these people have also proposed that it is effective to perform insulating processing as a cause which specific resistance does not go up using the insulating stratification processing liquid which prevented generating of rust paying attention to rust being generated on magnetic powder at the time of the insulating stratification in JP,9-109074,A.
[0009]
[Problem(s) to be Solved by the Invention] However, even if it manufactures a dust core using the magnetic powder by which insulating processing was carried out by the above-mentioned Prior art, the specific resistance and the permeability of the dust core do not become not much large. When the cause which does not become large was investigated, it turned out that it is because some magnetic powder is condensing (secondary condensation). That is, even if the insulating layer is completely formed on magnetic powder at the time of the insulating stratification, when some magnetic powder was condensing and thermosetting resin powder is mixed at a back process, it is because the part which some magnetic powder which was being condensed exfoliates and

does not have an electric insulation layer in the front face of magnetic powder is exposed, consequently eddy current loss becomes large.

[0010] The purpose of this invention is offering the manufacture approach of a dust core and manufacturing installation which can stop eddy current loss small by forming an electric insulation layer in each of magnetic powder completely.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention according to claim 1 While carrying out insulating processing of the magnetic powder and forming an electric insulation layer in the front face of the magnetic powder concerned By mixing and fabricating resin into the magnetic powder in which the electric insulation layer was formed, it is characterized by performing crack processing which unravels secondary condensation of said magnetic powder before formation of said electric insulation layer in the manufacture approach of the dust core which manufactures a dust core.

[0012] Thus, since insulating processing of the magnetic powder which was being condensed will be carried out after separating into each if crack processing is performed before formation of an electric insulation layer, an electric insulation layer can be completely formed in each of magnetic powder. Consequently, when a part without an electric insulation layer is not exposed to the front face of magnetic powder even when thermosetting resin powder is mixed at a back process, and it fabricates as a dust core, the eddy current loss can be stopped small.

[0013] After said magnetic powder which performed said crack processing mixes the insulating stratification processing liquid containing phosphoric acid, boric acid, magnesium ion, a surfactant, and a rusr-proofer like claim 2, it is good to dry this mixture and to perform insulating processing. If it does in this way, a thin and good insulating electric insulation layer can be formed in a front face at magnetic powder.

[0014] Moreover, said crack processing can be performed by giving an impact and vibration to magnetic powder like claim 3 using the mixer or ball mill of a V type or W cone mold. When carrying out crack processing using the above-mentioned mixer or a ball mill, the crack time amount for 60 minutes or more is required at the time of the rotational speed of 20 - 30rpm, and its crack time amount for 90 minutes or more is desirable. In addition, if it cracks for 120 minutes, it is enough, and the crack exceeding 120 minutes is useless.

[0015] An insulating processing means for invention according to claim 4 to carry out insulating processing of the magnetic powder, and to form an electric insulation layer in the front face of the magnetic powder concerned, In the manufacturing installation of a dust core including a mixed means to mix resin into the magnetic powder with which said electric insulation layer was formed, and a shaping means to fabricate the magnetic powder after resin mixing and to manufacture a dust core It is characterized by establishing a crack processing means to perform crack processing which unravels secondary condensation of said magnetic powder before formation of said electric insulation layer.

[0016] According to the above-mentioned configuration, crack processing of the magnetic powder can be carried out with a crack processing means before formation of an electric insulation layer, and the eddy current loss when fabricating as a dust core can be small stopped like the case where it is claim 1.

[0017] As a crack processing means, there is the mixer or ball mill of the V type which gives an impact and vibration to magnetic powder, or W cone mold like claim 5.

[0018] Claim 6 and invention according to claim 7 relate to the magnetic powder by which crack processing was carried out. That is, invention according to claim 6 is weight, and is characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 5 - 10% of -74-62 micrometers, the particle size of -62-45 micrometers, and 5% or less of 45-micrometer or less particle size.

[0019] Moreover, invention according to claim 7 is weight, and is characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 10 - 20% of -74-62 micrometers, 10 - 20% of particle size of -62-45 micrometers, and 10 - 20% of 45-micrometer or less particle size.

[0020] Claim 8 and invention according to claim 9 relate to the core fabricated using the magnetic powder of claim 6 and claim 7. Namely, in the core which invention according to claim 8 mixed to resin the magnetic powder which has an electric insulation layer, and was fabricated, said magnetic powder is weight. It is characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30%

of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 5 - 10% of -74-62 micrometers, the particle size of -62-45 micrometers, and 5% or less of 45-micrometer or less particle size.

[0021] Moreover, in the core which invention according to claim 9 mixed to resin the magnetic powder which has an electric insulation layer, and was fabricated, said magnetic powder is weight. It is characterized by having the particle size of 20 - 30% of 150 micrometers or more, the particle size of 20 - 30% of -150-106 micrometers, the particle size of 20 - 30% of -106-74 micrometers, the particle size of 10 - 20% of -74-62 micrometers, 10 - 20% of particle size of -62-45 micrometers, and 10 - 20% of 45-micrometer or less particle size.

[0022]

[Embodiment of the Invention] Below, the gestalt of operation of this invention is explained according to a drawing. Drawing 1 is the flow chart having shown the production process of the dust core concerning this invention. As shown in drawing, in step 100, crack processing of magnetic powder is performed first. This crack processing is performed before insulation processing at the following step 101. This point is the description part of this invention. Usually, some magnetic powder is condensed (secondary condensation) and it can unravel condensation of magnetic powder by performing crack processing to magnetic powder. Such crack processing can be performed using crack processors, such as a mixer of a V type or W cone mold, or a ball mill. About this, it mentions later.

[0023] As for the magnetic powder which crack processing was carried out [powder] and had condensation solved, insulating processing is performed in step 101. It has dissociated separately and the magnetic powder which had condensation solved can form an electric insulation layer in the front face of each of magnetic powder by performing insulating processing at homogeneity. And it is mixed in step 102 and the magnetic powder with which the electric insulation layer was formed in the front face is further dried in step 103.

[0024] Next, in step 104, as adhesives, the thermosetting of polyimide resin etc. is added to magnetic powder, and is mixed. Then, in step 105, it is fabricated by compression as a dust core. And finally in step 106, hardening processing is dried and carried out.

[0025] As equipment for performing the above-mentioned crack processing, there is a crack processor of drawing 2 or drawing 3 . Drawing 2 is a V type mixer. This V type mixer 1 has the V type container 2 made from stainless steel, and revolving shafts 3 and 4 are attached in the left and right laterals of this V type container 2. As for the revolving shaft 4, the revolving shaft 3 is supported respectively free [rotation] to the bearing 7 at bearing-bar 6 tip by bearing 5. Moreover, the roll control section 8 which controls rotation of the V type container 2 is formed, and the motor is formed in the interior of this roll control section 8.

[0026] The magnetic powder P is thrown in in the V type container 2 from input port 2A or 2B. When rotating the V type container 2, a lid (not shown) is attached in input port 2A or 2B, and the inside of the V type container 2 is sealed. And by carrying out the rotation drive of the revolving shaft 3 by the motor in the roll control section 8, the V type container 2 rotates in the direction of arrow-head A of drawing, and the magnetic powder P in the V type container 2 is cracked. The cracked magnetic powder P is discharged from exhaust port 2C of the V type container 2 lower part, and is collected by the container 9 for recycling arranged at V type container 2 lower part. In addition, the rotational frequency of the V type container 2 is set as 20 - 30rpm here.

[0027] Drawing 3 is a ball mill. This ball mill 10 has a container 11, and two or more balls 12 are held in this container 11. The container 11 and the ball 12 are formed by SUS304. Fin 11A for heat dissipation is prepared in the peripheral face of a container 11.

[0028] A lid 13 is attached in opening 11B, after preparing opening 11B in the upper part of a container 11 and throwing in the magnetic powder P in a container 11. The revolving shaft 14 is attached in the center section of the lid 13, and while preventing this revolving shaft's 14 pressing down a lid 13, and a lid 13 separating from it from a container 11, a container 11 can be rotated in the direction of arrow-head B by rotating a revolving shaft 14 (rotation). Moreover, the gas installation valve 15 and the vacuum valve 16 are attached in the lid 13.

[0029] In case crack processing of the magnetic powder P in a container 11 is carried out, after carrying out vacuum suction of the inside of a container 11 through the vacuum valve 16, Ar (argon) is introduced in a container 11 from the gas installation valve 15. And while rotating a revolving shaft 14, the container 11 whole is rotated in the direction of arrow-head C focusing on O of drawing (revolution). Although the centrifugal force of the direction of arrow-head D tends to join a ball 12 and a ball 12 tends to approach the 1 side (right-hand

side of drawing) of a container 11 by making it rotate in the direction of arrow-head C Since the container 11 is rotating centering on the revolving shaft 14 (rotation), a ball 12 will be returned a side (left-hand side of drawing) besides a container 11, and a ball 12 will be violently moved to right and left inside a container 11 after all. By this It becomes possible to crack the magnetic powder P thrown into the container 11 interior. In addition, a ball 12 is magnitude with a diameter of 10mm, and is put in 200 pieces to 250g of magnetic powder, and the rotational frequency of the rotation direction of a container 11 is set as 150rpm here.
[0030] As a crack processor, the V type mixer, and not only a ball mill but W cone mixer mentioned above can also crack the magnetic powder P. Moreover, high pressure gas is sprayed on the magnetic powder P in a container, you may make it stir the magnetic powder P, a supersonic wave is given to the magnetic powder P in a container, and you may make it vibrate the magnetic powder P violently.
[0031] Next, the example of this invention is explained.
[0032]
[Example 1] First, these people paid their attention about the relation between iron loss and specific resistance, and found out by experiment that specific resistance could be small stabilized by iron loss in 2 or more ohm-cm as shown in drawing 4 . Then, the target specific resistance value was made into 2 or more ohm-cm. However, when a long-term life is taken into consideration, 10 ohm-cm is desirable.
[0033] Atomization spherical iron powder with a mean particle diameter of 70 micrometers was supplied to the V type mixer, and while preparing the crack magnetism powder which performed crack processing for 30 minutes, 60 minutes, 90 minutes, 120 minutes, and 240 minutes with the rotational speed of 30rpm, respectively, the magnetic powder which does not perform crack processing for a comparison was prepared.
[0034] Moreover, as insulating stratification processing liquid, 20g of phosphoric acid, 4g of boric acid, and MgO4g were dissolved in 1l. of water, and what added EF-104 (product made from TOKEMI products) as a surfactant, and added benzotriazol 0.04mol as a rusr-proofer 0.1% of the weight was prepared.
[0035] Added 50 mols of insulating stratification processing liquid to 1kg of each magnetic powder, mixed for 30 minutes using the V type mixer, it was made to dry for 60 minutes at 180 degrees C using a warm air cycloid type thermostat, and insulating processing of a magnetic powder child front face was performed.
[0036] Next, polyimide resin was added 2% of the weight as adhesives, and after carrying out addition mixing of the lithium stearate 0.1% of the weight as a release agent, metal mold was filled up and it pressed by the pressure of 500MPa. Then, it hardened at 200 degrees C for 4 hours, and the 60mmx10mmx10mm pillar-shaped dust core test piece was produced.
[0037] The large specific resistance of effect was measured to iron loss and eddy current loss using this test piece. A measurement result is shown in drawing 5 . It is clearer than drawing 5 by cracking magnetic powder that specific resistance higher than the case where it does not crack is obtained. Moreover, it turns out that specific resistance becomes large as crack time amount becomes long, and 2 or more ohm-cm of target specific resistance is obtained in crack time amount 60 minutes. Moreover, although the value beyond specific resistance 10 ohm-cm is acquired in crack time amount 90 minutes, even if it cracks till 120 minutes, it is thought that the crack of the magnetic powder which the effectiveness of the increment in specific resistance is not acquired, but is till 120 minutes, and was condensed beyond it is completed completely.
[0038] The specific resistance of the dust core acquired can be made to increase from the above result by performing crack processing into magnetic powder before formation of an electric insulation layer. As crack time amount, 90 - 120 minutes is more preferably appropriate for 60 to 120 minutes.
[0039]
[Example 2] Drawing 6 is the particle size distribution when changing crack time amount and cracking by the V type mixer to magnetic powder with a particle size of 150 micrometers or less. Crack time amount was made into 1 hour, 2 hours, and 4 hours. Moreover, the particle size distribution of magnetic powder [that it is unsettled for a comparison (raw material powder)] are also shown.
[0040] As shown in drawing, to unsettled magnetic powder, the thing with a particle size of 150 micrometers is decreasing on the base of 20% by performing crack processing to 35% or more existing. In connection with this, the rate of a particle with a particle size of less than 150 micrometers has increased.
[0041]
[Example 3] Drawing 7 is the particle size distribution when cracking to magnetic powder with a particle size of 150 micrometers or less for 4 hours using a ball mill. Among drawing, the crack processing 1 is as a result of an

example 2 (it cracks for 4 hours using a V type mixer), and the crack processing 2 is as a result of this example. Moreover, the particle size distribution of magnetic powder [that it is unsettled for a comparison (raw material powder)] are also shown.
[0042] As shown in drawing, since crack energy is large technique compared with the crack processing 1, the rate of magnetic powder with a large particle size decreased, and the particle of crack processing 2 with a small particle size has increased.
[0043] Moreover, Table 1 shows the value of the specific resistance when performing crack processing 2 to crack processing 1 list. Although crack processing of magnetic powder was performed before formation of insulating processing, it turns out that specific resistance is large.
[0044]
[Table 1]

圧粉磁心の固有抵抗 (単位:Ω・cm)

試料	原料粉末処理	成形体		硬化体	
比較材	未処理	73		5.3	
		77		6.3	
		36	(62)	3.3	(5.0)
本発明	解砕処理1	90		73	
		128		90	
		147	(122)	95	(86)
	解砕処理2	49295		1253	
		35278		963	
		66973	(50515)	1903	(1373)

※ ( ) 平均値

[0045]
[Effect of the Invention] Since secondary condensation of magnetic powder is unraveled by performing crack processing before formation of an electric insulation layer according to this invention as explained above, even if it mixes thermosetting resin powder after the electric insulation stratification, the eddy current loss when the electric insulation layer not exfoliating and fabricating to a dust core can be stopped small. Consequently, permeability becomes it is high and possible [acquiring the dust core where iron loss is small].

[Translation done.]

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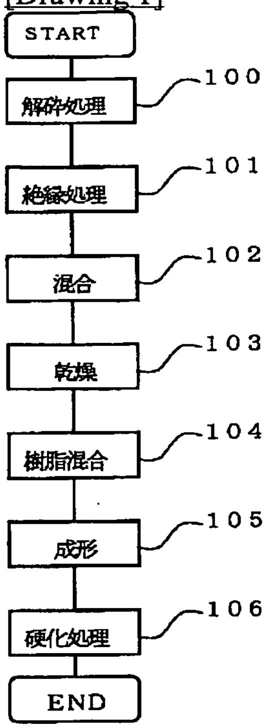
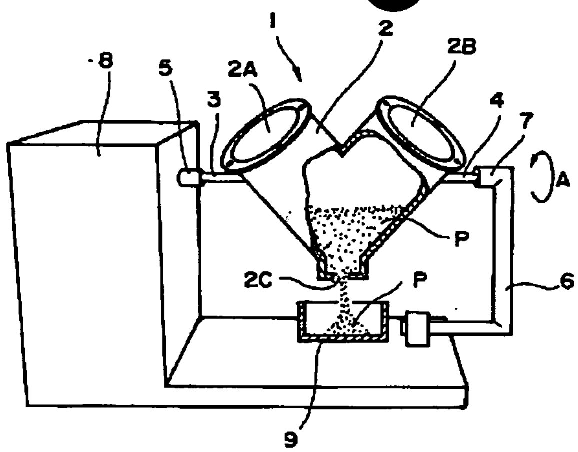
DRAWINGS

[Drawing 1]

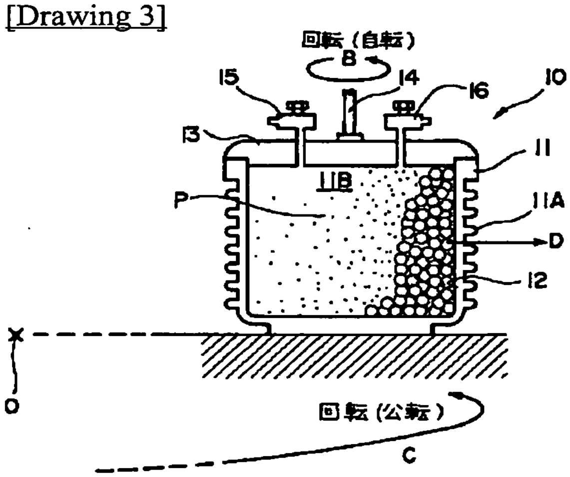


[Drawing 2]



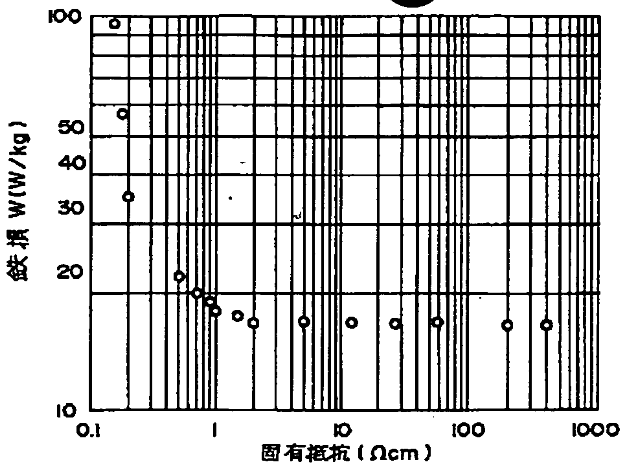
1：V型ミキサー
2：V型容器
3，4：回転軸
8：回転制御部
9：回収容器
P：磁性粉

[Drawing 3]

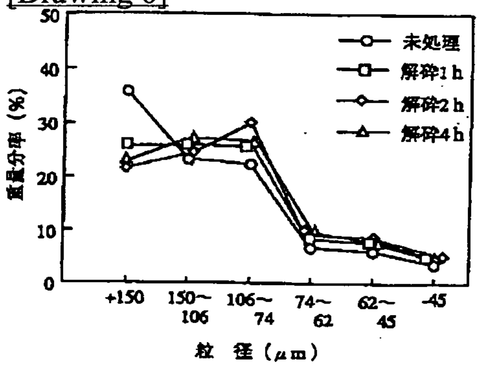


10：ボールミル
11：容器
12：ボール
13：蓋体
14：回転軸
15：ガス導入弁
16：真空弁
P：磁性粉

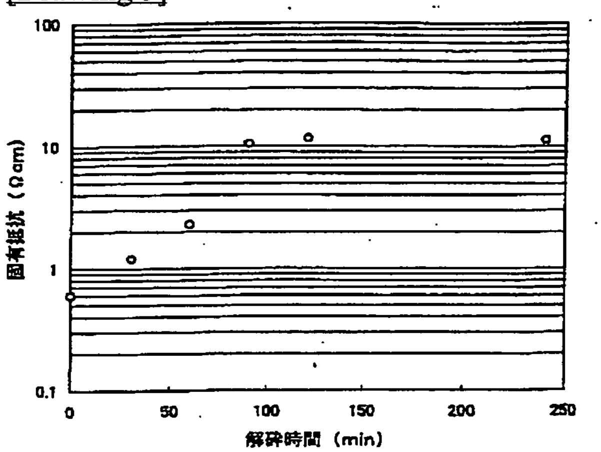
[Drawing 4]



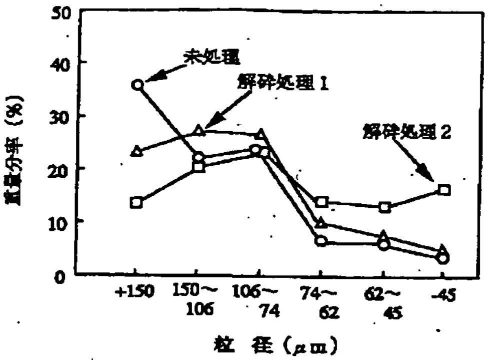
[Drawing 6]



[Drawing 5]



[Drawing 7]



[Translation done.]

CORRECTION OR AMENDMENT

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H01F  41/02         D
B22F   3/00         B
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[Procedure revision]
[Filing Date] December 20, Heisei 12 (2000. 12.20)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] In the manufacture approach of the dust core which manufactures a dust core by mixing and fabricating resin into the magnetic powder in which the electric insulation layer was formed while carrying out insulating processing of the magnetic powder and forming an electric insulation layer in the front face of the magnetic powder concerned,
The manufacture approach of the dust core characterized by performing crack processing which unravels secondary condensation of said magnetic powder before formation of said electric insulation layer.
[Claim 2] In the manufacture approach of a dust core according to claim 1,
The manufacture approach of the dust core characterized by drying this mixture and carrying out insulating processing of said magnetic powder after mixing the insulating stratification processing liquid which contains phosphoric acid, boric acid, magnesium ion, a surfactant, and a rusr-proofer in said magnetic powder which performed said crack processing.
[Claim 3] In the manufacture approach of a dust core according to claim 1,
Said crack processing is the manufacture approach of the dust core characterized by being carried out by giving an impact and vibration to magnetic powder using the mixer or ball mill of a V type or W cone mold.

[Claim 4] In the manufacturing installation of a dust core including an insulating processing means to carry out insulating processing of the magnetic powder, and to form an electric insulation layer in the front face of the magnetic powder concerned, a mixed means to mix resin into the magnetic powder with which said electric insulation layer was formed, and a shaping means to fabricate the magnetic powder after resin mixing and to manufacture a dust core,
The manufacturing installation of the dust core characterized by establishing a crack processing means to perform crack processing which unravels secondary condensation of said magnetic powder before formation of said electric insulation layer.
[Claim 5] In the manufacturing installation of a dust core according to claim 4,
Said crack processing means is the manufacturing installation of the dust core characterized by being the mixer or ball mill of the V type which gives an impact and vibration to magnetic powder, or W cone mold.
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] 0018
[Method of Amendment] Deletion
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] 0019
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[Document to be Amended] Specification
[Item(s) to be Amended] 0021
[Method of Amendment] Deletion

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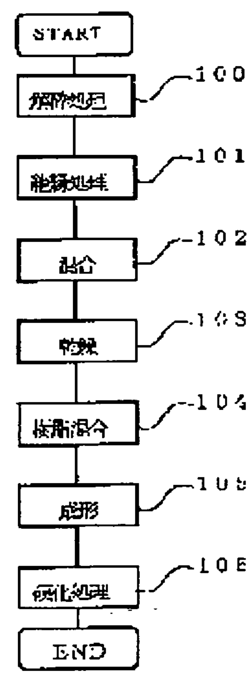
(54) METHOD AND DEVICE FOR MANUFACTURING DUCT CORE

(57)Abstract:
PROBLEM TO BE SOLVED: To suppress eddy current loss in a dust core by perfectly forming an electric insulating layer for each magnetic powder grain.
SOLUTION: In a step 100, a cracking process wherein a secondary coagulation of the magnetic powder is released is performed. This cracking process is performed before an insulation process in the net step 101. The magnetic powder wherein the secondary coagulation is released is performed with an insulation process in the step 101, for evenly forming an electric insulation layer on each surface of the magnetic powder. The magnetic powder wherein the electric insulation layer is formed on the surface is mixed in a step 102, and dried in a step 103. Then in a step 104, a polyimide resin, etc., is added as a bonding agent to the magnetic powder for mixing. After that, in a step 105, it is molded to a dust core under compression. Lastly, it is dried in a step 106.



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[0036] Then, as an adhesive, 2 % by weight of a polyimide resin was added, 0.1 % by weight of lithium stearate as a releasing agent was added, the materials were mixed, the mixture was charged into a mold, which was compression-molded at a pressure of 500 MPa. Thereafter, hardening at 200°C for 4 hours afforded a pillar dust core test piece of 60mm × 10mm × 10mm.

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(54)【発明の名称】　圧粉磁心の製造方法及び製造装置

(57)【特許請求の範囲】

【請求項１】　磁性粉を絶縁処理して当該磁性粉の表面に電気絶縁層を形成するとともに、その電気絶縁層を形成した磁性粉に樹脂を混合して成形することにより、圧粉磁心を製造する圧粉磁心の製造方法において、
前記電気絶縁層の形成前に前記磁性粉の二次凝集を解きほぐす解砕処理を行うことを特徴とする圧粉磁心の製造方法。

【請求項２】　請求項１に記載の圧粉磁心の製造方法において、
前記解砕処理を行った前記磁性粉に、燐酸、硼酸、マグネシウムイオン、界面活性剤及び防錆剤を含む絶縁層形成処理液を混合した後、該混合物を乾燥させ前記磁性粉を絶縁処理することを特徴とする圧粉磁心の製造方法。

【請求項３】　請求項１に記載の圧粉磁心の製造方法において、

前記解砕処理は、Ｖ型又はＷコーン型のミキサーもしくはボールミルを用いて、磁性粉に衝撃や振動を与えることによって行われることを特徴とする圧粉磁心の製造方法。

【請求項４】　磁性粉を絶縁処理して当該磁性粉の表面に電気絶縁層を形成する絶縁処理手段と、前記電気絶縁層が形成された磁性粉に樹脂を混合する混合手段と、樹脂混合後の磁性粉を成形して圧粉磁心を製造する成形手段と、を含む圧粉磁心の製造装置において、
前記電気絶縁層の形成前に前記磁性粉の二次凝集を解きほぐす解砕処理を行う解砕処理手段を設けたことを特徴とする圧粉磁心の製造装置。

【請求項５】　請求項４に記載の圧粉磁心の製造装置において、

前記解砕処理手段は、磁性粉に衝撃や振動を与えるＶ型又はＷコーン型のミキサーもしくはボールミルであることを特徴とする圧粉磁心の製造装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は圧粉磁心の製造方法及び製造装置に関するものである。

【０００２】

【従来の技術】一般に、高周波用変圧器、リアクトル、サイリスタバルブ、ノイズフィルタ、チョークコイル等の高周波コイルとして圧粉磁心が用いられている。このような圧粉磁心は、低鉄損でかつ高磁束密度であることは勿論のこと、それらの磁気特性が高周波領域においても低下しないことが求められている。

【０００３】鉄損には磁心の固有抵抗値と関係が深い渦電流損と、磁性粉（鉄粉）の製造過程及びその後のプロセス履歴から生じるヒステリシス損とがある。このうち渦電流損は周波数の二乗に比例して大きくなるので、高周波での特性を向上させるためには、渦電流損を下げることが重要となる。渦電流損を下げるには渦電流を小さな領域に閉じ込めればよいので、一般的には、個々の粒子が絶縁された磁性粉から圧粉磁心が製造されている。

【０００４】従来の製造方法としては、磁性粉を絶縁処理して、磁性粉の表面に電気絶縁層を形成し、その電気絶縁層が形成された磁性粉に接着剤として樹脂を混合するとともに圧縮により成形を行って、圧粉磁心を製造する圧粉磁心の製造方法が知られている。

【０００５】しかし、上記製造方法では、電気絶縁層による絶縁が不十分であると、渦電流損が大きくなるという欠点がある。絶縁性を良くするために電気絶縁層を厚くすることが考えられるが、電気絶縁層が厚くなると磁心中の磁性粉の占める割合が低下し、結果的に磁束密度が低下してしまう。また、磁束密度を向上させるために密度を上げようとして、高圧力で圧縮成形すると成形時の歪が大きくなり、ヒステリシス損が大きくなり、鉄損の増大を招いてしまう。

【０００６】良好な圧粉磁心を製造するには、密度を下げることなく圧粉磁心の固有抵抗を上げることが重要であり、そのためには、薄くて且つ絶縁性の良好な電気絶縁層で磁性粉を覆うことが必要である。

【０００７】このような電気絶縁層を形成する方法として、磁性粉に対して燐酸塩化成処理を施すことが、特開平６−２６０３１９号公報、特開昭６２−２２４１０号公報、及び特開昭６３−７０５０４号公報等において開示されている。

【０００８】また、本出願人も特開平９−１０９０７４号公報において、固有抵抗が上がらない原因として、絶縁層形成時に錆が磁性粉上に発生することに着目し、錆の発生を防止した絶縁層形成処理液を用いて絶縁処理を施すのが効果的であることを提案している。

【０００９】

【発明が解決しようとする課題】しかしながら、上記従来の技術によって絶縁処理された磁性粉を用いて圧粉磁心を製造しても、その圧粉磁心の固有抵抗及び透磁率はあまり大きくはならない。大きくならない原因を調べてみると、磁性粉の一部が凝集（二次凝集）しているためであることが分かった。すなわち、絶縁層形成時に磁性粉上に完全に絶縁層が形成されていても、磁性粉の一部が凝集していると、後工程で熱硬化性樹脂粉を混合したときに、凝集していた磁性粉の一部が剥離して磁性粉の表面に電気絶縁層のない部分が露出し、その結果、渦電流損が大きくなるからである。

【００１０】本発明の目的は、磁性粉の一つ一つに電気絶縁層を完全に形成することにより、渦電流損を小さく抑えることのできる圧粉磁心の製造方法及び製造装置を提供することである。

【００１１】

【課題を解決するための手段】上記目的を達成するために、請求項１に記載の発明は、磁性粉を絶縁処理して当該磁性粉の表面に電気絶縁層を形成するとともに、その電気絶縁層を形成した磁性粉に樹脂を混合して成形することにより、圧粉磁心を製造する圧粉磁心の製造方法において、前記電気絶縁層の形成前に前記磁性粉の二次凝集を解きほぐす解砕処理を行うことを特徴としている。

【００１２】このように、電気絶縁層の形成前に解砕処理を行っておけば、凝集していた磁性粉は一つ一つに分離されてから絶縁処理されるので、磁性粉の一つ一つに電気絶縁層を完全に形成することができる。その結果、後工程で熱硬化性樹脂粉を混合したときでも、磁性粉の表面に電気絶縁層のない部分が露出することはなく、圧粉磁心として成形したときに、その渦電流損を小さく抑えることができる。

【００１３】前記解砕処理を行った前記磁性粉は、請求項２のように、燐酸、硼酸、マグネシウムイオン、界面活性剤及び防錆剤を含む絶縁層形成処理液を混合した後、該混合物を乾燥させて絶縁処理を行うとよい。このようにすると、磁性粉に表面に薄くて且つ絶縁性の良好な電気絶縁層を形成することができる。

【００１４】また、前記解砕処理は、請求項３のように、Ｖ型又はＷコーン型のミキサーもしくはボールミルを用いて、磁性粉に衝撃や振動を与えることによって行うことができる。上記ミキサーやボールミルを用いて解砕処理する場合、２０〜３０ｒｐｍの回転速度のときは、６０分以上の解砕時間が必要で、９０分以上の解砕時間が好ましい。なお、１２０分解砕すれば充分であり、１２０分を越えての解砕は無駄である。

【００１５】請求項４に記載の発明は、磁性粉を絶縁処理して当該磁性粉の表面に電気絶縁層を形成する絶縁処理手段と、前記電気絶縁層が形成された磁性粉に樹脂を混合する混合手段と、樹脂混合後の磁性粉を成形して圧

粉磁心を製造する成形手段と、を含む圧粉磁心の製造装置において、前記電気絶縁層の形成前に前記磁性粉の二次凝集を解きほぐす解砕処理を行う解砕処理手段を設けたことを特徴としている。
【００１６】上記構成によれば、電気絶縁層の形成前に、解砕処理手段によって磁性粉を解砕処理することができ、請求項１の場合と同様に、圧粉磁心として成形したときの渦電流損を小さく抑えることができる。
【００１７】解砕処理手段としては、請求項５のように、磁性粉に衝撃や振動を与えるＶ型又はＷコーン型のミキサーもしくはボールミルがある。
【００１８】
【００１９】
【００２０】
【００２１】
【００２２】
【発明の実施の形態】以下に、本発明の実施の形態を図面に従って説明する。図１は本発明に係る圧粉磁心の製造工程を示した流れ図である。図に示すように、まず、ステップ１００において磁性粉の解砕処理が行われる。この解砕処理は、次のステップ１０１での絶縁処理以前に行われる。この点が本発明の特徴部分である。通常、磁性粉の一部は凝集（二次凝集）しており、磁性粉に対して解砕処理を行うことにより、磁性粉の凝集を解きほぐすことができる。このような解砕処理は、Ｖ型又はＷコーン型のミキサーもしくはボールミル等の解砕処理装置を用いて行うことができる。これについては後述する。
【００２３】解砕処理されて凝集を解かれた磁性粉は、ステップ１０１において絶縁処理が行われる。凝集を解かれた磁性粉は個々に分離しており、絶縁処理を行うことによって、磁性粉の一つ一つの表面に電気絶縁層を均一に形成することができる。そして、表面に電気絶縁層が形成された磁性粉は、ステップ１０２において混合され、更にステップ１０３において乾燥される。
【００２４】次に、ステップ１０４において、接着剤としてポリイミド樹脂等の熱硬化性が磁性粉に加えられ混合される。その後、ステップ１０５において、圧縮により圧粉磁心として成形される。そして最後に、ステップ１０６において乾燥し硬化処理される。
【００２５】上記解砕処理を行うための装置としては、図２や図３の解砕処理装置がある。図２はＶ型ミキサーである。このＶ型ミキサー１はステンレス製のＶ型容器２を有し、このＶ型容器２の左右側面には回転軸３，４が取り付けられている。回転軸３は軸受５に、回転軸４は支持棒６先端の軸受７にそれぞれ回転自在に支持されている。また、Ｖ型容器２の回転を制御する回転制御部８が設けられ、この回転制御部８の内部にはモータが設けられている。
【００２６】磁性粉Ｐは投入口２Ａ又は２ＢからＶ型容器２内に投入される。Ｖ型容器２を回転させるときは、投入口２Ａ又は２Ｂには蓋体（図示せず）が取り付けられ、Ｖ型容器２内は密閉される。そして、回転制御部８内のモータで回転軸３を回転駆動することによって、Ｖ型容器２は図の矢印Ａ方向に回転し、Ｖ型容器２内の磁性粉Ｐが解砕される。解砕された磁性粉ＰはＶ型容器２下部の排出口２Ｃから排出され、Ｖ型容器２下方に配置された回収容器９に回収される。なお、ここではＶ型容器２の回転数は２０～３０ｒｐｍに設定されている。
【００２７】図３はボールミルである。このボールミル１０は容器１１を有し、この容器１１の中には複数個のボール１２が収容されている。容器１１及びボール１２共にＳＵＳ３０４で形成されている。容器１１の外周面には放熱用フィン１１Ａが設けられている。
【００２８】容器１１の上部には開口部１１Ｂが設けられ、容器１１内に磁性粉Ｐを投入した後には、開口部１１Ｂには蓋体１３が取り付けられる。蓋体１３の中央部には回転軸１４が取り付けられており、この回転軸１４は蓋体１３を押さえて蓋体１３が容器１１から外れるのを防ぐとともに、回転軸１４を回転させることによって、容器１１を矢印Ｂ方向に回転（自転）させることができる。また、蓋体１３にはガス導入弁１５と真空弁１６が取り付けられている。
【００２９】容器１１内の磁性粉Ｐを解砕処理する際には、真空弁１６を介して容器１１内を真空引きした後、ガス導入弁１５から容器１１内にＡｒ（アルゴン）を導入する。そして、回転軸１４を回転させるとともに、容器１１全体を図のＯを中心にして矢印Ｃ方向に回転（公転）させる。矢印Ｃ方向に回転させることによって、ボール１２には矢印Ｄ方向の遠心力が加わり、ボール１２は容器１１の一側（図の右側）に寄ろうとするが、回転軸１４を中心にして容器１１が回転（自転）しているので、ボール１２は容器１１の他側（図の左側）戻され、結局、ボール１２は容器１１の内部で左右に激しく動かされることになり、これによって、容器１１内部に投入された磁性粉Ｐを解砕することが可能となる。なお、ここではボール１２は直径１０ｍｍの大きさで、磁性粉２５０ｇに対して２００個入れられ、容器１１の自転方向の回転数は１５０ｒｐｍに設定されている。
【００３０】解砕処理装置としては、上述したＶ型ミキサーやボールミルだけでなく、Ｗコーン型ミキサーでも磁性粉Ｐを解砕することができる。また、容器内の磁性粉Ｐに高圧ガスを吹き付けて磁性粉Ｐを攪拌するようにしてもよいし、容器内の磁性粉Ｐに超音波を与えて磁性粉Ｐを激しく振動させるようにしてもよい。
【００３１】次に本発明の実施例について説明する。
【００３２】
【実施例１】まず、本出願人は、鉄損と固有抵抗の関係について着目し、図４に示すように固有抵抗が２Ω・ｃｍ以上で鉄損が小さく安定できることを実験により見い

出した。そこで、目標とする固有抵抗値は２Ω・ｃｍ以上とした。但し、長期の寿命を考慮すると１０Ω・ｃｍが望ましい。

【００３３】平均粒径７０μｍのアトマイズ球状鉄粉をＶ型ミキサーに投入し、３０ｒｐｍの回転速度で３０分、６０分、９０分、１２０分及び２４０分間の解砕処理を施した解砕磁性粉をそれぞれ用意するとともに、比較のため解砕処理を行わない磁性粉を用意した。

【００３４】また、絶縁層形成処理液として、水１リットルに、燐酸２０ｇ、硼酸４ｇ、ＭｇＯ４ｇを溶解し、界面活性剤としてＥＦ－１０４（トーケミプロダクツ製）を０．１重量%、防錆剤としてベンゾトリアゾール０．０４ｍｏｌを加えたものを用意した。

【００３５】それぞれの磁性粉１ｋｇに対し絶縁層形成処理液を５０ｍｏｌ添加し、Ｖ型ミキサーを用いて３０分間混合し、温風循環型恒温槽を用いて１８０℃で６０分間乾燥させ、磁性粉粒子表面の絶縁処理を行った。

【００３６】次に、接着剤としてポリイミド樹脂を２重量%添加し、離型剤としてステアリン酸リチウムを０．１重量%添加混合した後、金型に充填し、５００ＭＰａの圧力で圧縮成形した。その後、２００℃で４時間硬化して、６０ｍｍ×１０ｍｍ×１０ｍｍの柱状圧粉磁心試験片を作製した。

【００３７】この試験片を用いて鉄損及び渦電流損に影響の大きい固有抵抗を測定した。測定結果を図５に示す。図５より、磁性粉を解砕することによって、解砕しない場合より高い固有抵抗が得られることが明らかである。また、解砕時間が長くなるにつれて固有抵抗が大きくなり、解砕時間６０分で目標とする固有抵抗２Ω・ｃｍ以上が得られることが分かる。また、解砕時間９０分で固有抵抗１０Ω・ｃｍ以上の値が得られるが、１２０分まで解砕してもそれ以上の固有抵抗増加の効果は得られず、１２０分までで、凝集した磁性粉の解砕が完全に終了しているものと考えられる。＊

＊【００３８】以上の結果から、電気絶縁層の形成以前に磁性粉に解砕処理を行っておくことにより、得られる圧粉磁心の固有抵抗を増加させることができる。解砕時間としては６０～１２０分、より好ましくは９０～１２０分が妥当である。

【００３９】

【実施例２】図６は、粒径１５０μｍ以下の磁性粉に対し、解砕時間を変えてＶ型ミキサーで解砕したときの粒度分布である。解砕時間は、１時間、２時間及び４時間とした。また、比較のために、未処理（原料粉）の磁性粉の粒度分布も示してある。

【００４０】図から分かるように、未処理の磁性粉には粒径１５０μｍのものが、３５%以上存在するのに対し、解砕処理を施すことで、２０%台に減少している。これに伴い、粒径１５０μｍ未満の粒子の割合が多くなっている。

【００４１】

【実施例３】図７は、粒径１５０μｍ以下の磁性粉に対し、ボールミルを用いて４時間解砕したときの粒度分布である。図中、解砕処理１は実施例２（Ｖ型ミキサーを用いて４時間解砕）の結果であり、解砕処理２は本実施例での結果である。また、比較のために、未処理（原料粉）の磁性粉の粒度分布も示してある。

【００４２】図から分かるように、解砕処理２は、解砕処理１に比べて解砕エネルギーが大きい手法であるので、粒径の大きい磁性粉の割合が減少し、粒径の小さい粒子が多くなっている。

【００４３】また表１は、解砕処理１並びに解砕処理２を施したときの固有抵抗の値を示している。絶縁処理の形成以前に、磁性粉の解砕処理を施したものの固有抵抗は大きいことが分かる。

【００４４】

【表１】

圧粉磁心の固有抵抗　　(単位:Ω・cm)

試料	原料粉末処理	成形体		硬化体	
比較材	未処理	73		5.3	
		77		6.3	
		36	(62)	3.3	(5.0)
本発明	解砕処理1	90		73	
		128		90	
		147	(122)	95	(86)
	解砕処理2	49295		1253	
		35278		963	
		66973	(50515)	1903	(1373)

※（　）平均値

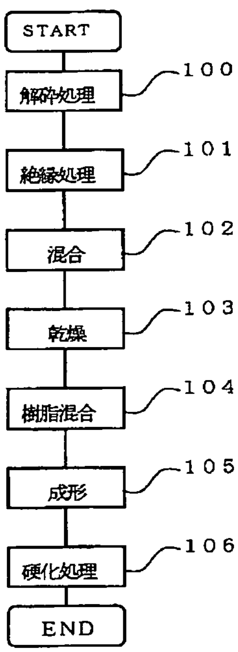
【００４５】

【発明の効果】以上説明したように、本発明によれば、電気絶縁層の形成以前に解砕処理を行うことにより、磁性粉の二次凝集が解きほぐされるので、電気絶縁層形成後に熱硬化性樹脂粉を混合しても、その電気絶縁層が剥離したりすることが無く、圧粉磁心に成形したときの渦電流損を小さく抑えることができる。その結果、透磁率が高く、鉄損の小さな圧粉磁心を得ることが可能となる。

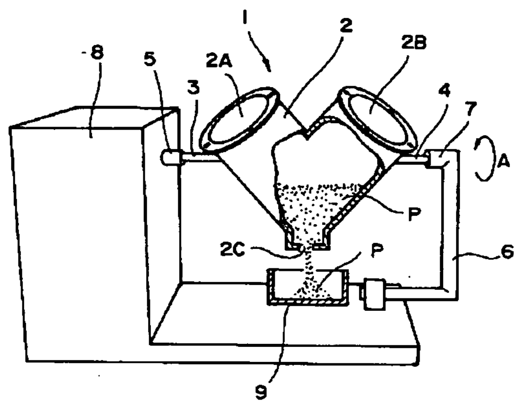
【図面の簡単な説明】

【図１】本発明に係る圧粉磁心の製造工程を示した流れ図である。
【図２】Ｖ型ミキサーの概略構成図である。
【図３】ボールミルの概略構成図である。
【図４】固有抵抗と鉄損との関係を示したグラフである。
【図５】磁性粉の解砕時間と得られる圧粉磁心の固有抵抗との関係を示すグラフである。
【図６】解砕時間を変えたときの磁性粉の粒度分布の変化を示した線図である。
【図７】解砕処理装置を変えたときの磁性粉の粒度分布の変化を示した線図である。
【符号の説明】
＊１　Ｖ型ミキサー
２　Ｖ型容器
３，４　回転軸
８　回転制御部
９　回収容器
１０　ボールミル
１１　容器
１２　ボール
１３　蓋体
１４　回転軸
１５　ガス導入弁
１６　真空弁
＊　Ｐ　磁性粉

【図１】

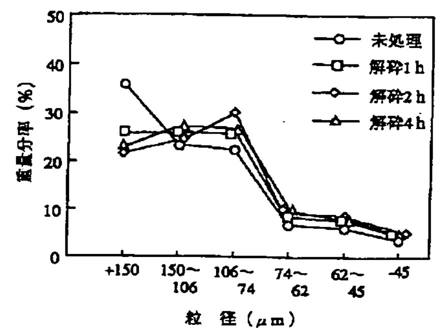


【図２】

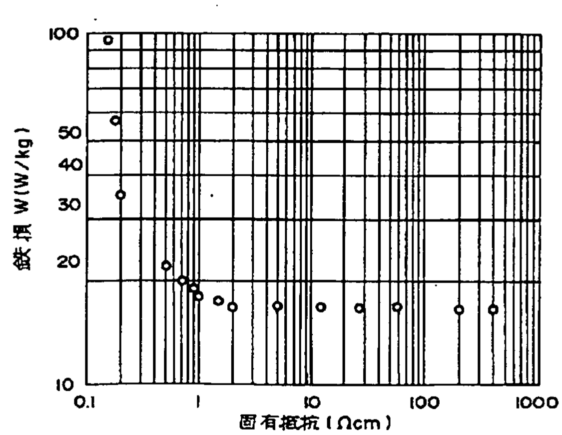


1：V型ミキサー
2：V型容器
3，4：回転軸
8：回転制御部
9：回収容器
P：磁性粉

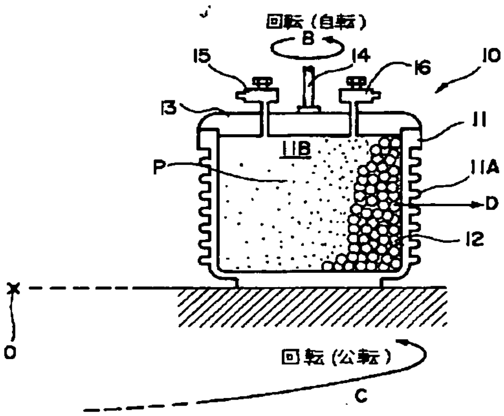
【図６】



【図４】

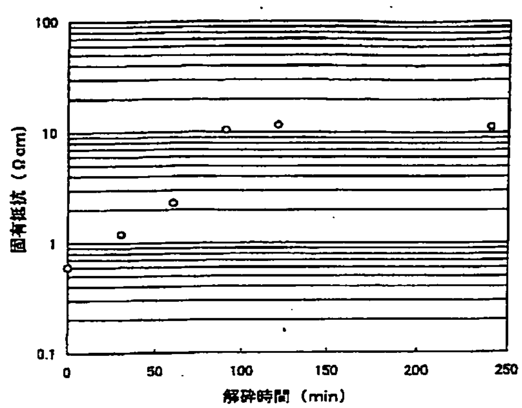


【図３】

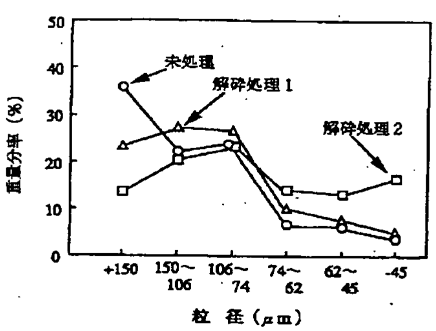


１０：ボールミル
１１：容器
１２：ボール
１３：蓋体
１４：回転軸
１５：ガス導入弁
１６：真空弁
　P：磁性粉

【図５】



【図７】



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(56)参考文献　特開　平６－260319（ＪＰ，Ａ）
特開　昭60－80205（ＪＰ，Ａ）
特開　平８－250317（ＪＰ，Ａ）
特開　平１－220407（ＪＰ，Ａ）

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